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A COMPARISON OF THE INVERTEBRATE FAUNA UNDER *Eucalyptus* AND *Pinus* FORESTS IN THE OTWAY RANGES, VICTORIA

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Abstract: The invertebrates under a mature *Eucalyptus regnans* forest and a mature *Pinus radiata* plantation were sampled in May 1975. When the invertebrates from these sites were compared, marked differences were found in most groups.

INTRODUCTION

Plantations of exotic softwoods (predominantly *Pinus radiata* D. Don) have replaced native forests in many parts of Australia, and there has been considerable discussion about the extent to which the establishment of such plantations affects native fauna.

Studies on invertebrates associated with introduced conifers in Australia have been few, and have taken a predominantly pest management approach (Campbell 1971, Minko 1961, Moore 1963, 1972).

Unlike vertebrates, which are often highly vagile, many invertebrates depend closely upon components of native vegetation for their survival. Little attention has been paid to invertebrates associated with pine plantations, to the detailed reasons for elimination of particular taxa, or to the ecological consequences of such elimination. The presence of an animal in pine forest does not necessarily imply permanent occupancy, nor ability to survive and reproduce in that habitat. Many of the vertebrates and flying insects may be transient in pines, while other species may survive in pines but require continual repopulation from adjacent native areas, e.g. Forster and Wilton (1973).

METHODS

During 18-19 May 1975, the invertebrate fauna in mature, unlogged *Eucalyptus regnans* F. Muell. forests and mature *Pinus radiata* plantations in the central Otway Ranges was sampled. Only the invertebrate macrofauna and mesofauna as defined by Murphy (1955) were studied.

Four study sites, each of approximately two ha were selected; the *P. radiata* sites were located 6 km SSW. of Beech Forest in the Aire Valley Plantation and the *E. regnans* sites were 2-3 km S. and SW. of the pine sites. Two different aspects (NW. and SW.) were chosen in pines (May 18) and duplicated in eucalyptus (May 19).

One 50 m transect containing three equidistant circular quadrats of 3 m radius was established along the contour at each site. Within each quadrat the understorey vegetation between the substrate and the 2 m level was sampled by beating; a 10 x 10 cm litter sample and a 10 x 10 x 10 cm soil sample were also taken. One 20 x 20 cm bark sample was taken from each of four individuals of the dominant tree species near the transect, each sample being at a different aspect (N., S., E. and W.) and at a height of 0-30 cm from ground level. At each site, a random search was made for macrofauna within 25 m on either side of the transect and 10 litter depth measurements were recorded. The same time was spent in random searching at each site.

The soil, litter and bark invertebrates were extracted using Tullgren funnels. Most animals were sorted into apparent species, but for a number of taxa (Oligochaeta, Pseudoscorpionida, Acarina, Pauropoda, Diplopoda, Symphyla and Lepidoptera) representatives were only counted, due to the difficulty involved in their identification. Numbers of individuals in all groups and/or species were tallied and these results were pooled for the two eucalypt sites and for the two pine sites. A complete list of animals and the numbers collected is given in Appendix 1. All tallies for Orders represented by 10 or more individuals were statistically analyzed (Simpson, Roe & Lewontin, 1960) whilst random search values shown in Appendix 1 were excluded from analysis.

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RESULTS

Eucalypts supported significantly more individuals (8868) than pines (3179) (Table 1). Similarly, eucalypts contained more species (169) than pines (65). The following taxa showed significant numerical dominance favouring eucalypts: Oligochaeta, Acarina, Arancae, Ostracoda, Isopoda, Pauropoda, Diplopoda, Collembola, Hemiptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Only four taxa of the 18 analyzed were not significantly different: Pseudo-scorpionida, Amphipoda, Chilopoda and Symphyla. Ostracoda and Paurapoda were absent from the pines, and Oligochaeta, Isopoda, Diplopoda, Diptera and Hymenoptera were poorly represented (Table 1).

The eucalypt understorey vegetation, soil and bark samples contributed significantly more individuals than the corresponding pine layers, whilst the litter contained more individuals per unit area under pines than under eucalypts (Table 2). The relative distribution of individuals and of species numbers throughout all eucalypt layers is significantly different from that of pine layers (Table 2).

DISCUSSION

At the time of sampling, marked differences were found in numbers of both individuals and species occurring under eucalypts and pines, and this may be considered in the light of the greater heterogeneity of the understorey vegetation, soil, litter and bark components of the eucalypts. Results of random search (Appendix 1) show that 26 additional species were found in eucalypts and 35 in pines, possibly because the more open, homogeneous pine habitat permitted a more thorough search to be made.

The higher number and diversity of invertebrates in eucalypt understorey vegetation may be explained by the greater floristic density and diversity in the eucalypts (G. W. Carr, pers. comm.). Many phytophagous insects are host plant dependent and thus are eliminated from habitats lacking suitable hosts. The reduced spider fauna in pines, especially species requiring suitable structures upon which to suspend webs (e.g. Argiopidae), reflect the inadequacy of pine understorey in providing microhabitats. This factor would be limiting in pines regardless of prey availability.

The influence of soils upon the soil fauna, which was markedly reduced in pines when compared to eucalypts, was not ascertained.

The small numbers of both individuals and species in the pine bark are associated with the persistent nature of the *P. radiata* bark, which offers fewer microhabitats than does the sub-persistent bark sampled on *E. regnans*.

Although litter under pines had fewer invertebrate

TABLE 1

TOTAL NUMBERS OF INDIVIDUALS COLLECTED IN *Eucalyptus* AND *Pinus* SITES. IN ORDERS WITH MORE THAN 10 SPECIES COLLECTED. THE NUMBER OF SPECIES IS IN PARENTHESIS.
χ^2 SIGNIFICANCE LEVELS (*) 0.05; (**) 0.01; (***) 0.005.

Taxa	No. Individuals		
	Eucalyptus	*Pinus*	χ^2
Oligochaeta	25	4	15.20***
Pseudoscorpionida	26	21	0.54 n.s.
Acarina	5739	2454	1317.13 ***
Araneae	145 (37)	48 (19)	48.76 ***
Ostracoda	664	0	664.00 ***
Amphipoda	18	12	1.20 n.s.
Isopoda	113	2	107.14 ***
Pauropoda	90	0	90.00 ***
Diplopoda	77	3	68.46 ***
Chilopoda	9	5	1.14 n.s.
Symphyla	3	7	2.28 n.s.
Collembola	1131 (7)	518 (8)	227.88 ***
Hemiptera	33 (13)	15 (5)	6.76 **
Coleoptera	312 (47)	44 (14)	201.76 ***
Diptera Larvae	114 (20)	11 (6)	84.88 ***
Adults	34 (14)	3 (5)	8.34 ***
Lepidoptera	24	3	16.34 ***
Hymenoptera	288 (24)	4 (4)	276.22 ***
Total	8868 (169)	3179 (65)	

TABLE 2

TOTAL NUMBERS OF INDIVIDUALS AND SPECIES IN DIFFERENT SAMPLING LAYERS IN *Eucalyptus* AND *Pinus* SITES. χ^2 SIGNIFICANCE LEVELS (*) 0.05; (***) 0.005.

	Eucalyptus		*Pinus*		χ^2	
	Individuals	Species	Individuals	Species	Individuals	Species
Understorey vegetation	1156	87	160	36	753.81***	10.57***
Soil	1720	62	757	11	374.39***	17.82***
Litter	1579	47	2028	28	55.89***	4.81*
Bark	4413	57	234	21	3758.13***	5.68*
					$\chi^2_{\frac{2}{3}}$=2686.54***	$\chi^2_{\frac{2}{3}}$=46.22***

species than under eucalypts, the number of individuals per unit area in the pine litter is greater than that in the eucalypt. Taking into account the litter depths in pines (5.8 cm) and eucalypts (2.6 cm), the actual density of invertebrates was higher in eucalpts. The reduced species richness of the pine litter may be due partly to the homogeneous composition of the litter and partly to the chemical nature of the pine needles (e.g. Etherington 1975).

The invertebrate fauna of the understorey vegetation, soil, litter and bark layers under the eucalypts showed greater species richness and higher numbers of individuals than under the pines, at the time of sampling. This is probably due to the greater structural complexity of the eucalypt habitat. However, further studies are necessary to ascertain whether similar trends are found at other times of the year and at other sites. It is also necessary to ascertain the importance of the history of the pine site prior to planting, the ability of invertebrates to recolonize after plantation establishment, and the ability to utilize pine habitat.

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APPENDIX 1

Numbers of Individuals Taken in Understorey Vegetation, Soil, Litter and Bark Samples in *E. regnans* and *P. radiata* Sites.

V Understorey vegetation; numbers/169.65 m^2 (6 x 28.27 m^2 samples). **S** Soil; numbers/6000 cm^2 (6 x 1000 cm^2 samples). **L** Litter; numbers/600 cm^2 (6 x 100 cm^2 samples). **B** Bark; numbers/3200 cm^2 (8 x 400 cm^2 samples). **R** Random search. * Individuals not differentiated beyond taxon shown. ** Immature stages for insects.

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B.	R.
ANNELIDA										
*Oligochaeta		5	18	2		2	1	1		
*Hirudinea					2					3
ARTHROPODA										
Arachnida										
*Pseudoscorpionida	3	2		21		1		1	19	
Opiliones sp. A			4	1				1		
B			1	1						
*Acarina	765	995	823	3156		29	683	1585	157	
Araneae										
Dipluridae sp. A				2	6					
Oonopidae sp. A							1			
Dysderidae sp A									2	
Oecobiidae sp. A				1						
Dictynidae sp. A					2					
B					1					
C	3									
Salticidae sp. A	6			2						
B			1						3	3
C								1		6
D										2
E										1
Clubionidae sp. A						1				5
B	2					1				1
C	1									
Symphytognathidae sp. A		2	2			1		3	1	
B								1		
Mimetidae sp A								1		
Gnaphasidae sp. A					3					
B					1					
Thomisidae sp. A	4									1
B										1
C				1						
D			1							
E	1									
Theridiidae sp. A	1									
B	4					1		1	2	
C	2								1	
D						3			2	
E	2									

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B	R.
F	6					1				
G	1									
H	1									
I	1									
Linyphiidae sp. A			1					1		
B										1
C		3								
D	1									
Argiopidae sp. A	3									1
8	11									1
C	46					10				10
D	13					6				
E	1									
F	6									
G	2									
H	1					1				1
I						1				
J					1					
K	1									
L	1									
Agelenidae sp. A					1					
8			1							1
C										
D				4				1	1	
Pisauridae sp. A					1					
8										301
Lycosidae sp. A		1								
8		2								
Crustacea										
Ostracoda										
Cypridídae sp. A		239	424	1						
Amphipoda										
Tallitridae sp. A	7	2	7	2		7		5		
Isopoda										
Oniscidae sp. A	46	4	6	56				2		
Armadillidae sp. A			1							
*Pauropoda				90						
*Diplopoda		43	16	18		2			1	
Chilopoda										
Geophilidae sp. A		1	2	3				1	1	
8		1		1						
Lithobiidae sp. A				1	2			3		
Crytopidae sp. A					2					
Symphyla										
*Scutigerellidae			1	2			7	1		
Insecta										
Collembola										
Poduridae sp. A	8	26	56	811		2	47	166	24	
B	8	35	10	83			1	208	2	
C		1		3				2	1	

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B.	R.
D								4		
Isotomidae sp. A	2	1		20		6	1		2	
Entomobryidae sp. A	40	2	8	10		12	3	13	1	
B	2							2		
Sminthuridae sp. A	3		1	1		21				
Diplura										
Campodeidae sp. A				1						
Japygidae sp. A		1	1				4			
Archagocnatha										
Meinertellidae sp. A							1			
Blattodea										
Blatellidae sp. A	1			1	5					
B					1					
Isoptera										
*Termitidae					6					
Plecoptera										
Nemouridae sp. A					1					1
Orthoptera										
Gryllacrididae sp. A										2
Tetrigidae sp. A								1		
Phasmatodea										
Phasmatidae sp. A	1									
Embioptera										
Oligotomidae sp. A									1	
Psocoptera										
Liposcelidae sp. A		1	1							
Philotarsidae sp. A										1
B	1									
C	1									
Peripsocidae sp. A	2									
Ectopsocidae sp. A										1
Caeciliidae sp. A						1				1
B						1				1
Psocidae sp. A	1									
Hemiptera-Homoptera										
Cixiidae sp. A	1									
Delphacidae sp. A						2				
Cicadellidae sp. A	1									
B										1
C	1									
Membracidae sp. A	1**									
Psyllidae sp. A	1									
B						1				
C		3**						4**		
Aphididae sp. A					1					1**
Coccidae sp. A		4					3	1	2	
Hemiptera-Heteroptera										
Nabidae sp. A										1
Reduviidae sp. A		1		3						
Saldidae sp. A	1									
Lygaeidae sp. A		2	6	1			2			
B		1								

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B.	R.
C		1	4							
Gelastocoridae sp. A		1								
Thysanoptera										
Phlaeothripidae sp. A	1									
B	1									
Neuroptera										
Hemerobiidae sp. A	1									1
Coleoptera										
Sphaeriidae sp. A		9**							2**	
Carabidae sp. A			1**			2(1**)				
B	1**	2**	1**							
C				1						
Ptiliidae sp. A				9						
Scydmaenidae sp. A	2	1		1		4				
B				1		1				
Scaphidiidae sp. A	7									
B				2						
Staphylinidae sp. A						1			1**	
B	1		1	3						
C		5		3						
D		9								
E		45								
F		4	1	2				1		
G		1								
Pselaphidae sp. A				16						1
B				1						
Scarabaeidae sp. A		2**		1**						
Elateridae sp. A				1**						
B						1**				
C		11**								
D	1**	1**								
E		1**								
F					1**					
G		1**		1**						
H				1**						
I				1**						
Eucnemidae sp. A		3**	1**	21**					2**	
Anobiidae sp. A						1**				
Cleridae sp. A				2**						
Corylophidae sp. A	6									1
Coccinellidae sp. A									1	
Lathridiidae sp. A	1								3	
B										1
Ciidae sp. A					1					
Tenebrionidae sp. A		1								
B				1						
C				1						
Lagriidae sp. A		5**		6**						
Melandryidae sp. A	3			1						
Chrysomelidae sp. A		1**								
Curculionidae sp. A	39	5	4	7		12				
B	5									

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L	B	R.
C	5									
D	5			2						
E	1									
F	1	1		1		2				
G		11	1							
H			1	2						
I					1					
J		1								
K		1		4						
L				1						
M	2	2				4		6		
Diptera, larvae										
Nematocera sp A		1								
B		1								
C		10	7					1		
D		3								
E		1	24							
F		2	1							
G		1								
H		1								
I			1							
J			2							
K			1							
L			1							
M			2							
N								1		
O					1					
Brachycera sp. A		2					2	2		
B		24						3		
C								1		
D							1			
E		1	16	1						
F			5							
G			3							
H				1						
I					1					
J			2							
Diptera, adults										
Tipulidae sp. A	9					10				
B	2									
C			1							
Psychodidae sp. A	1									
Chironomidae sp. A	1					1				1
B					1					
C					1					
D	1									
Simuliidae sp. A						1				
Bibionidae sp. A					1					
Cecidomyiidae sp. A	1					1				
B										1
Sciaridae sp. A	3									1
B	1			1						1

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B	R.
C	1									
D	8		1							
Rhagionidae sp. A					1					
Empididae sp. A										2
Dolichopodidae sp. A	1				1	1				
Syrphidae sp. A										1
Sphaeroceridae sp. A			1							
Chloropidae sp. A	1									
*Lepidoptera										
Eriocraniidae	1									1
Tortricidae			1**	1**						
Psychidae	1**									
?Phyllocnistidae	1**									
Glyphipterygidae	1									
Oecophoridae		1**	9**	5**						
Geometridae		1**								
Lasiocampidae									1**	
Notodontidae						2**				
Arctiidae	1**									1**
Noctuidae	1**									1**
Hymenoptera										
Ichneumonidae sp. A										1
B	1									
Braconidae sp. A										1
B	1									
C			1							
Proctotrupidae sp. A										1
B	3									
C		1								
Platygasteridae sp. A				5						
Scelionidae sp. A	1									
B				3						
C				1						
D				1						
E	1									
Diapriidae sp. A									1	
B	1	1								
C						1				
D	2									
E			1							
Eulophidae sp. A						1				
Mymaridae sp. A	1									
B	1									
Pteromalidae sp. A	1					1				
Formicidae sp. A			1							
B		1	1							1
C		160	90		13					1
D				1						1
E	3									
F				1						
G	3									

Appendix 1 (continued)

	Eucalyptus sites					Pinus sites				
	V	S.	L	B.	R.	V.	S.	L.	B	R.
MOLLUSCA										
Choropidae										
Pernagera tamarensis					1					
Pillomera meroia					1					
Pillomera sp.								1		
Helicorionidae										
Heliocarion niger					1					
Cystopeltidae										
Cystopelta purpura					1					
Rhytididae										
Victaphanta compacta					2					4
Rhytida ? gawleri					1					